Space Weather Technical Forecast

Issued on Sunday, 09 January 2022 at 01:01 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1/Minor Storm likely early on Day 1 (Sunday 9th January). Increasing Slight Chance of M-class flares (R1-R2 radio blackouts).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Very Low over the past 24 hours. There are currently four sunspots on the visible disc. The two notable sunspot regions are currently AR2924, which is at the solar meridian as a Ehi/Beta; and the second notable sunspot in the southeast quadrant as a Hax/Alpha. The trend in both these regions was towards consolidation, albeit with slight areal growth. AR2924 saw some proliferation of intermediate spots in the first half of the period, however this behaviour waned as the UTC day progressed. There are currently two unnumbered sunspots on the visible disc, one in the northern hemisphere, near to the meridian, as a small and simple Axx/Alpha. The other unnumbered sunspot is currently rotating onto the southeast limb, which is currently classified as a Hsx/Beta (bipolar), although a more detailed analyse of this sunspot will be needed due to the foreshortening effect as it rotates further onto the southeast quadrant. In addition to these regions, the eastern solar horizon is bright in EUV flux in both hemispheres, likely indicating some returning sunspots, although these have yet to present for analysis. There is a plage region associated with one of these bright flux regions beginning to rotate onto the northeast limb, which will continue to be monitored for any sunspot development.
No Earth-directed Coronal Mass Ejections (CMEs) have been observed in currently available imagery. Spells of bright flux emanating from a possible small filament leading 2924 on the disc were seen in the period, peaking 08/0600UTC, however these do not appear to have resulted in any CME. A high latitude CME visible in STEREO and Lasco coronagraphs in the period has been determined to be far-sided.

Solar Wind / Geomagnetic Activity: Solar winds, as observed by DSCOVR and ACE at L1 were indicative of a slow regime throughout much of the period, before the onset of a CIR (Co-rotating Interacting Region), which preceded entry into the expected high speed stream (HSS) from coronal hole 43. Solar winds were steady at around 300km/s throughout, before rising to become slightly elevated with the onset of the HSS at around 470km/s by the end of the period.
Phi angle was predominately positive (away from the sun) before the onset of the CIR ahead of the HSS from CH43/-, switching to negative (towards the sun) from 08/2015UTC. Density was initially at normal background levels around mid-single figures ppcc, however this climbed during the UTC morning to reach a peak near 50ppcc in the suggested CIR, before a gradual decline with the onset of the HSS. The IMF was predominately weak, until the onset of the CIR, becoming strong, with a peak of 20nT at 08/1830UTC, before a steady decline back to Moderate levels, at around 10nT to end the period. The all important north-south component varied between +/-4nT at the start of the period, with a strong southward orientation from 08/1800UTC with the onset of the CIR, with the Bz falling to a value of -16nT at 08/1849UTC. The net result of the above solar wind measures was initially Quiet geomagnetic activity, with an Active (Kp4) in the 18-21UTC interval and a G1/Minor Storm (kp5) observed in the 21-00UTC interval.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV)

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remained at Background levels throughout.

High energy electron flux (greater than 2MeV) ranged between Moderate and High, peaking at 2700pfu at 08/1805UTC, before returning to background levels due to increased geomagnetic activity within the CIR ahead of the HSS from CH43.
Electron fluence remained below the Active threshold (1e8 integrated pfu) on a steady trend, with 5.87e7 integrated pfu recorded at 09/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to remain Low, with further C-class flares possible. In addition, there is an increasing daily Slight Chance of M-class flares, as numerous large returning regions are expected to rotate onto the visible disc over the UTC weekend.

Solar Wind / Geomagnetic Activity: There are currently no Earth-directed CMEs in the forecast, and just one non-recurrent coronal hole, CH43. Geomagnetic activity is expected to be Active (kp4) at first, with a G1/Minor Storm likely early on day 1 (Sunday 9th January), and is currently expected to return back to Quiet to Unsettled conditions again from day 2 (Monday 10th January).

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is most likely to remain at background levels, albeit with a very slight increase in risk with the westward progression of the current front-sided sunspots.

The high energy electron flux oscillation (greater than 2MeV) may show an eventual slight increase in magnitude in the wake of the expected high speed stream from CH43, with a resultant Chance of Active fluence by the end of the four-day period after any initial apparent suppression.

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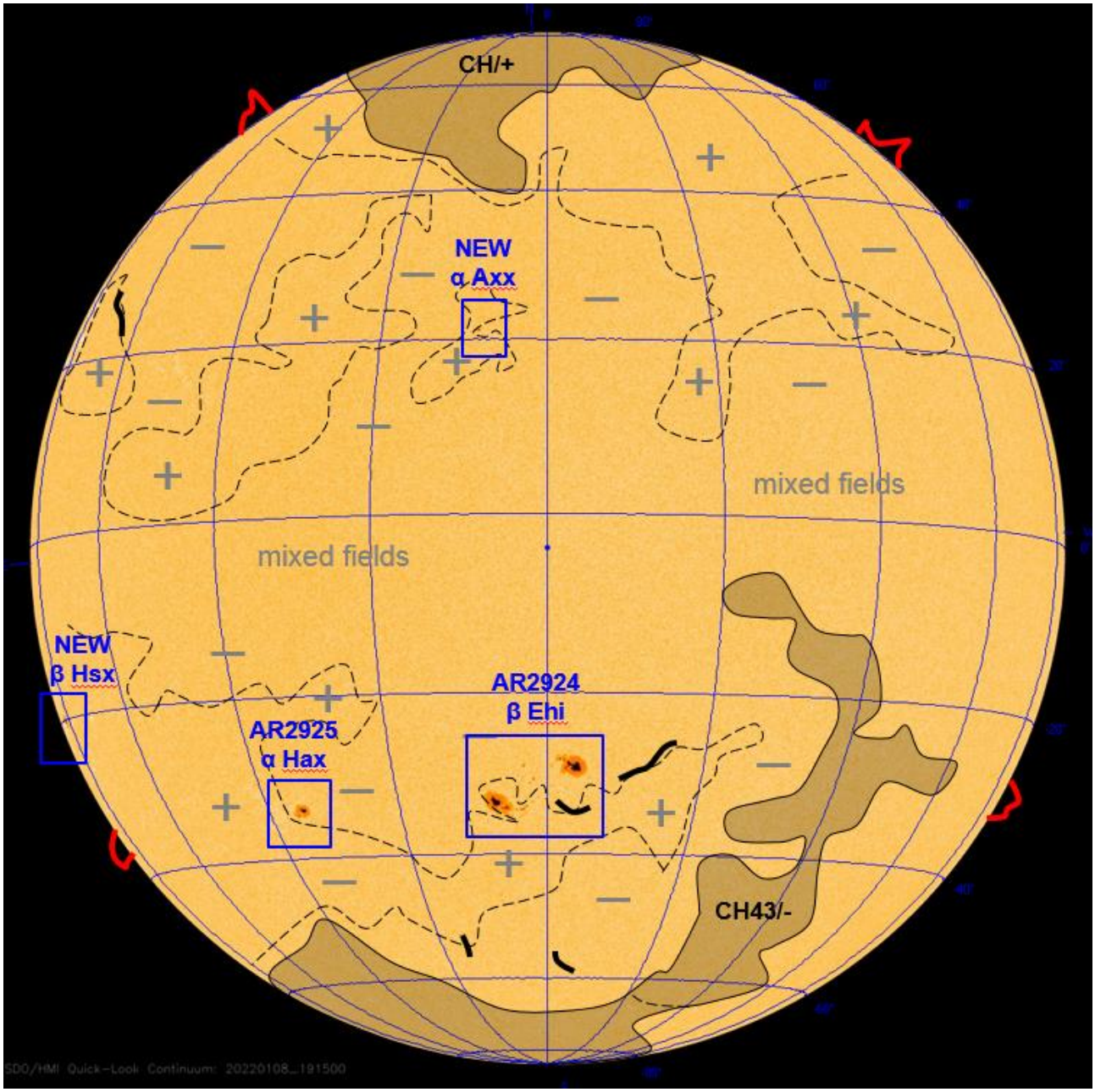
Figure 1. Solar Analysis Valid 08/1915UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

No Earth-directed CMEs feature in this forecast period.

The sole forecast feature in the geomagnetic forecast is the non-recurrent coronal hole 43 in the southern solar hemisphere. At the time of writing this forecast, evidence in the solar wind parameters suggests the arrival of a CIR (Co-rotating Interacting Region) ahead of the high speed stream (HSS) from coronal hole 43. Confidence was moderate with regards to the strength of this feature and at the time of writing this document, geomagnetic activity had already increased, with an Active (Kp4) interval at 08/1800-2100UTC. STEREO A suggests solar wind speeds to be around 400-450km/s, and are currently slightly elevated at around 420km/s at time of writing this forecast. This is felt to perhaps be underdone in terms of peak speeds - probably a result of the satellite sampling a higher solar latitude than Earth (0.5 North, versus Earth's 4.0 degrees South). The most likely wind speeds are considered to be elevated at around 500km/s, which looks reasonable at this stage.

Geomagnetic activity is expected to be Active (kp4) with a G1/Minor Storm likely early on Day 1 (Sunday 9th January) due to connection with a HSS from CH43. Activity is expected to return to Quiet to Unsettled on Day 2 (Monday 10 January), then predominately Quiet from Day 3 (Tuesday 11 January) as fast wind from coronal hole 43 wanes.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	50	5	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil.

Figure 2: BGS chart showing the current and recent geomagnetic activity in the UK and globally – shows the recent G1/Minor Storm (Kp5).

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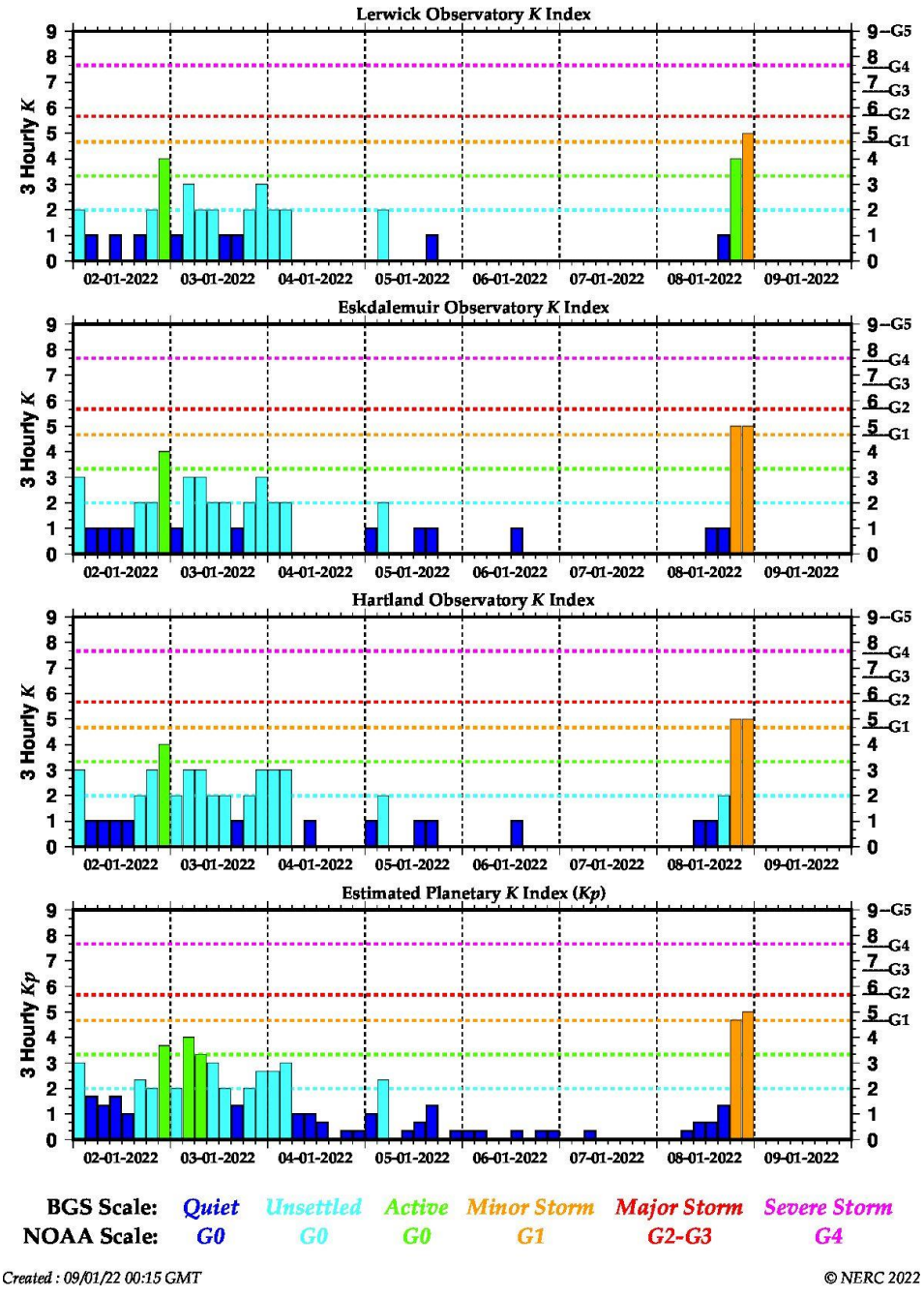
Lerwick Observatory K Index
Eskdalemuir Observatory K Index
Hartland Observatory K Index
Estimated Planetary K Index (Kp)
3 Hourly K
3 Hourly Kp
0 1 2 3 4 5 6 7 8 9
G1 G2 G3 G4 G5
02-01-2022 03-01-2022 04-01-2022 05-01-2022 06-01-2022 07-01-2022 08-01-2022 09-01-2022
BGS Scale: Quiet Unsettled Active Minor Storm Major Storm Severe Storm
NOAA Scale: G0 G0 G0 G1 G2-G3 G4
Created : 09/01/22 00:15 GMT
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Radio Blackouts - X-Ray Flares:

Solar activity has remained Very Low in the last 24 hours. STEREO A EUVI imagery suggests large bright flux regions occupy both solar hemispheres, with the southern cluster probably correlating with returning regions Ex-2907 and 2908, both M-class flare-producing regions on previous rotation. The northern hemisphere group is less certain, however this may be Ex-2911, which also gave an isolated M-class flare on its last outing. This group is currently plage rotating onto the northeast limb.

At the time of writing, there was no significant upsurge in background X-ray flux or flares observed, and coronagraph imagery does not yet hint at eastern limb CMEs, however the expected course of X-ray flux is upwards over the UTC weekend and into next week. The degree to which this occurs is uncertain, however a token 20% daily risk of M-class flares is suggested until they present for analysis.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	20	20	20	20
Very Active	R3 to R5 X Class	No	1	1	2	2

Figure 3: GOES X-Ray flares.

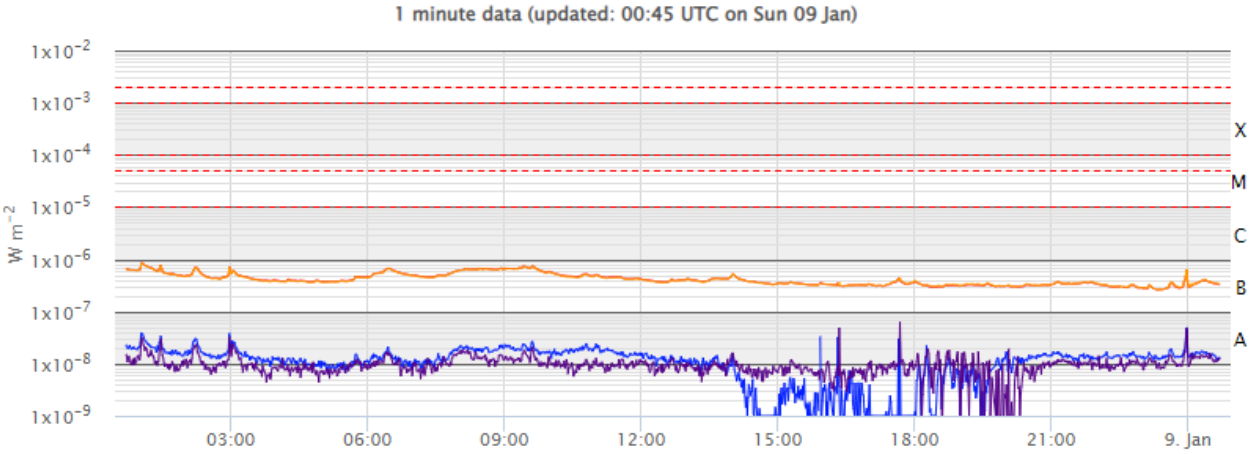

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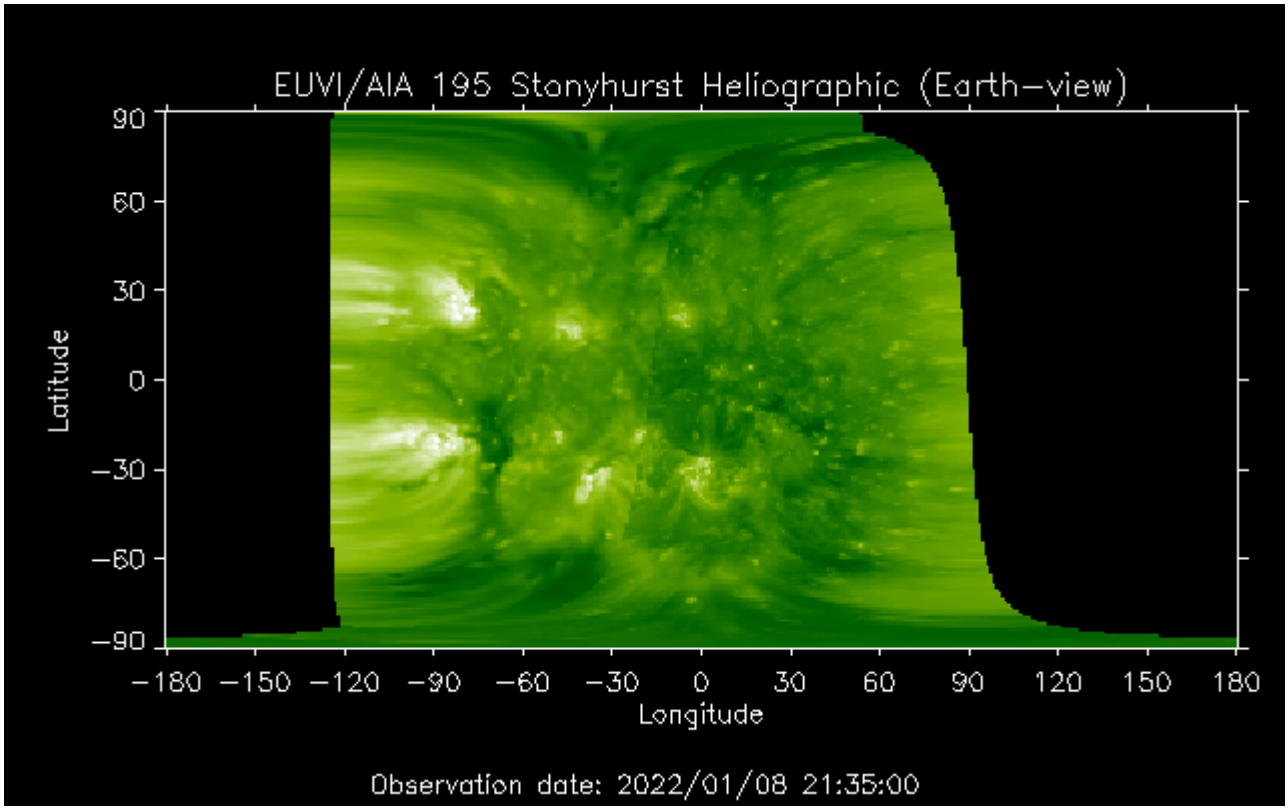
Figure 4: STEREO-A EUV 195 – shows bright flux regions approaching the east limb.



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is currently at Background levels and will most likely persist at this level in the absence of solar activity. There is a slightly increasing chance of S1 as a result of westward progression of the current front sided sunspot groups.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	1	2	2	2
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2MeV) as observed by GOES-16 has been at Moderate levels, with the diurnal peak exceeding the High threshold during the past 24 hours, with a peak value of 2700pfu at 08/1805UTC. However, the arrival of a CIR ahead of a high speed stream from CH43/- has suppressed flux levels back to Normal Background levels at GEO. An eventual increase in fluence is then possible from Day 2 (Monday 10 January), although the degree to which this manifests is not certain - due to CH43 being a novel feature.
The electron fluence is most likely to remain below the Active level (1e8 integrated pfu) throughout the four days, but with an increase in risk from Day 2 onwards (Monday 10 January), with an eventual Chance of reaching the Active threshold by the end of the period.
Modelling available to MOSWOC is not felt likely to be representative in the current set-up, given the non-persistent coronal hole that dominates the geomagnetic forecast.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	5	20	30	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: MOSWOC REFM electron fluence.

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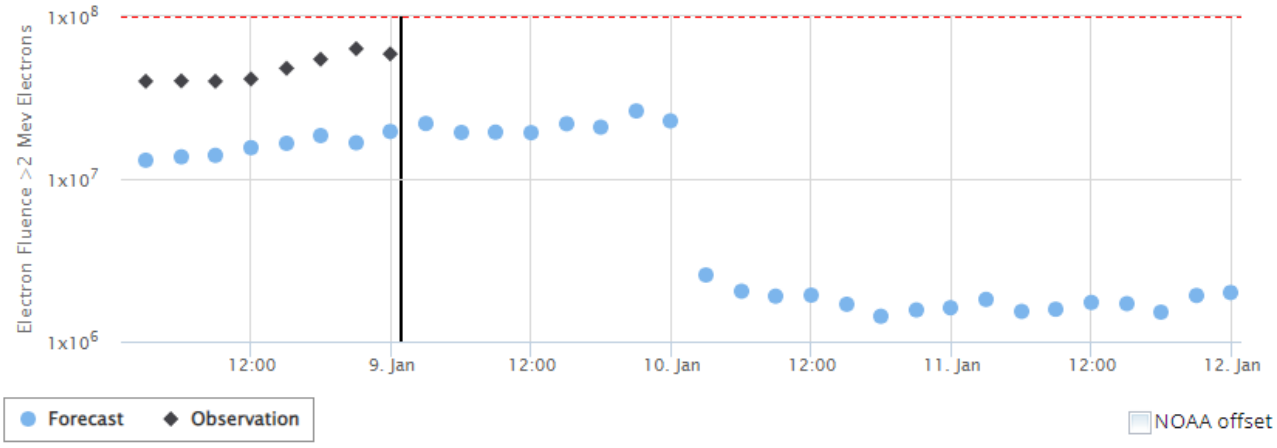

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